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MODELING HEDONIC PRICES IN SINGAPORE

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ABSTRACT

This paper presents hedonic regressions for the Singaporean residential real-estate market. To these means, asking prices were collected from an online commercial property portal in February 2011. Transaction prices were collected from governmental data sets. These data sets are enhanced with locational data, such as vicinity to bus stops, MRT stations, supermarkets, (top) primary schools and other points of interests. Models were estimated with standard OLS, spatial auto regressive and geographically weighted regression methods for several sub-markets: private rental & buying and public (HDB) rental & buying. Floor area and distance to CBD are the most important drivers of house price. Dependent on the market, vicinity to public transport has a positive result. A higher floor level is considered positive as well. Furthermore, we find that spatial models function better than traditional OLS models and that using asking prices and transaction prices yields similar results despite the large difference between both types of prices.

KEYWORDS

Hedonic pricing, spatial regression, Singapore, real-estate

1. INTRODUCTION

Policy questions in today's transportation and land-use planning increasingly require a smaller unit of measurement: a person and his activities. To these means both agent-based transportation demand models and land-use micro simulation have been developed. Increasingly, these models are being integrated. The research put forward in this paper concerns the extension of the agent-based transportation demand model MATSim (Balmer et al., 2006) with a land-use component for Singapore.

Hedonic prices and residential location choice play a key role in land-use. Hedonic regression is commonly applied to estimate the value of heterogeneous goods, such as housing units, which are heterogeneous through their immobility and resulting locating differences (Fahrländer, 2007). By applying the method, it is possible to capture the relative weight of the different characteristics. Hedonic regressions were applied first by Lancaster (1966) and is used to today for property taxation and mortgage underwriting, but also for property price generation in land-use and transport models (Löchl, 2010).

Phang (2007) provides a comprehensive overview of the Singaporean property market. Summarizing, the Singaporean property market is divided between private property and residential estates that are developed by the Housing Development Board (HDB). Private property varies from condominiums to landed houses (i.e. family houses in the main) and can be afforded by households with higher incomes. HDB provides Singaporeans the possibility to apply for a new flat if they meet certain requirements. The HDB resale market is open for Singaporean and permanent residents. In addition, both private and HDB properties can be rented. Approximately 80% of the building stock consists of HDB flats. Of the remaining 20% more than 10% of the stock consists of private condominiums.

Earlier hedonic studies for Singapore have either focused on a certain market (Ong et al., 2003) or on price differences between estates governed by the ruling party or by the opposition (Sue and Wong, 2010). Tu et al. (2005) provide insight into the upgrading behavior from public to private dwellings. A number of studies have been carried out for the Hong Kong case (Wong et al., 2005; Tse and Love, 2000; Tang and Chung, 2010; Jim and Chen, 2009). Tang and Chung (2010) introduce spaciousness in their study - the amount of internal vs external space within a condominium. They also find that proximity to MRT is valued positive. All studies show the importance of age and floor area.

Ordinary least square approaches are not able to account for spatial dependence and heterogeneity and will inevitably lead to biased parameter estimates. Therefore, in order to take into account the spatial effects, spatial autoregressive (SAR) (Anselin, 1988) as well as geographically weighted regression techniques (GWR) (Fotheringham et al., 2002) are applied in this study. This is discussed further in Section 2. Section 3 continues with an overview of the available data and the main descriptive statistics. In Section 4 the model estimation procedure is discussed. Section 5 concludes with a discussion and outlook.

The contribution of this study can be found in the combination and comparison of asking prices and transaction prices by using several data sources. Furthermore this studies contributes by applying hedonic regression for Singapore as a whole, with different types of spatial regression models.

2. METHODOLOGY

Following Anselin (1988) and Fotheringham et al. (2002), this study applies SAR and GWR models. According to Kissling and Carl (2008) spatial simultaneous autoregressive models can be divided into three subgroups depending on where the autoregressive process is expected to occur. Spatial autoregressive lag models (SARlag) assume that an inherent spatial autocorrelation is present in the response variable. If spatial dependence is assumed to appear in the disturbance process, an error vector u containing the spatial weights matrix is used. This leads to the so-called spatial error model (SARerr), which can be written as:

$$\begin{aligned} P &= \beta X + u \\ u &= \lambda W u + \varepsilon \\ \varepsilon &\sim N(0, \sigma^2 I_n) \end{aligned} \tag{1}$$

where P is a vector of housing prices, β is a vector of regression coefficients, X is a matrix with observations on explanatory characteristics, ε representing the error vector, λ is a spatial autoregressive coefficient and W is the spatial weights matrix which appears in the error term. If spatial autocorrelation is assumed to appear in both the explanatory and response processes, Kissling and Carl (2008) suggest to use the so-called spatial Durbin model (SARdurbin), which contains additionally a term $WX\gamma$ which describes the autoregression coefficient γ of the spatially lagged explanatory variables.

Besides the above described SAR models, GWR models are estimated. Fotheringham et al. (2002) point out that GWR estimate linear regressions for every data point in space using overlapping samples of the data. Therefore distance-dependent weights are used. GWR essentially allow parameters to vary over space, which can lead to an increased understanding of varying relationships between variables across space (Löchl, 2010).

3. AVAILABLE DATA & DESCRIPTIVE STATISTICS

3.1 Available data

For this study data is collected from several sources. On the one hand, information about property prices is required. A twofolded approach is chosen to obtain both asking and transaction prices. Webbots were written to collect property listings containing asking prices available on the commercial online property portal Property Guru (AllProperty, 2011) in February and March 2011. Private transactions were collected from REALIS database (URA, 2011), which is made available by the Urban Redevelopment Authority, the Singaporean government agency concerned with urban planning. HDB property resale transaction prices were collected through the HDB website (HDB, 2011a). Both types of transaction data were collected for Quarter 2 2010 until Quarter 1 of 2011.

Structural variables were collected from Property Guru and a second online property directory. Information on HDB upgrading programmes was collected from the HDB website (HDB, 2011b).

Points of interests were collected from several sources, most notably the NAVTEQ navigation network of Singapore (NAVTEQ, 2011), Streetdirectory (Streetdirectory, 2011), schools (Ministry of Education, 2011), top schools (PAEXCO, 2011) and supermarket websites (Giant, 2011; NTUC, 2011).

3.2 Comparison of market segments

3.2.1 Price comparison

Figure 1 clearly shows the price gaps between the different segments. The grey boxes represent fifty percent of the observations (2nd and 3rd quartile), the fat vertical line in the box represents the mean value and the thin one the median. The average asking price in the private sale market of 2'840'000 S\$ is about sixty percent higher than the average unit price of the transaction data (1'524'000 S\$). On the one hand, this can be explained because transaction prices look back, and asking prices provide a snapshot of the current market. Furthermore, it is believed that owners are advertising their apartment to see which price they can fetch for their property. It stands out that there is no big difference between asking and transaction prices in the HDB sector (asking prices are around 14% higher). Figure 1 also shows price differences for square meter prices (right hand side). In general the differences show the same structure as the absolute prices. The plots further show that the price differences between private and HDB flats are fairly large, as expected. The average transaction price of a private flat (1'524'000 S\$) is almost four times higher than the average HDB flat price (395'000 S\$). The average flat price not only varies between market segments but also across geographical space. Figure 3 shows the spatial price structure for the private and HDB sale markets. The maps clearly show that private prices vary stronger over space and increase towards the city centre.

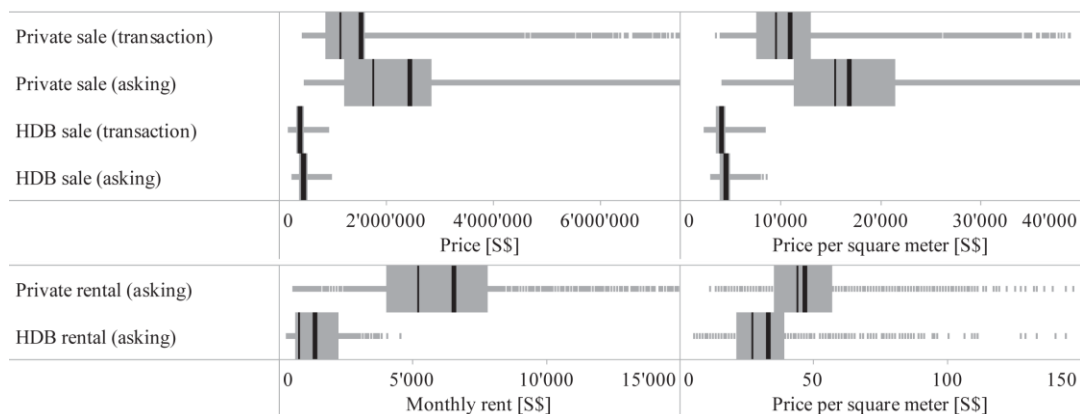


Figure 1. Comparison of unit prices and monthly rents

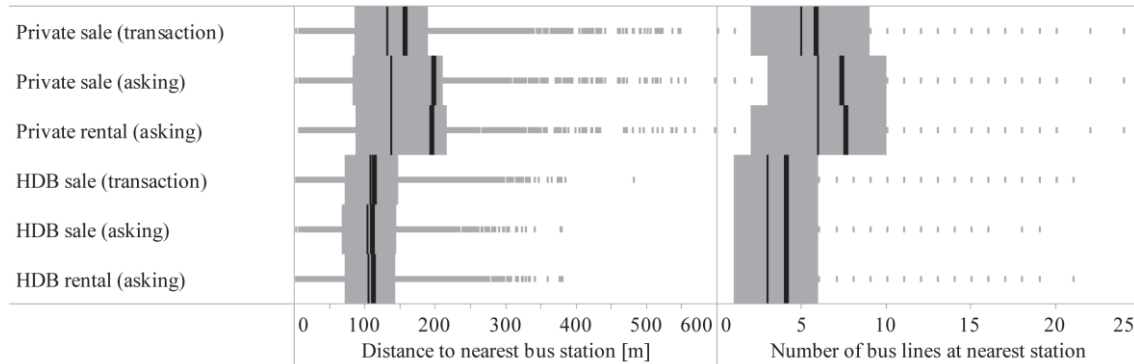


Figure 2. Comparison of distances to bus stop and number of bus lines

3.2.2 Locational comparison

Figure 2 shows that HDB flats are in average much closer to the nearest bus stop than private flats. But these stops provide only around four bus lines on average while the average nearest stop to private flats provides around seven lines. The proximity to bus stops of HDB flats (110 meters in average) can be explained with the high spatial concentration of HDB flats in HDB towns. These towns normally have centrally located access to public transportation. Both distances to bus stops and numbers of bus lines do not vary significantly between asking and transaction price data.

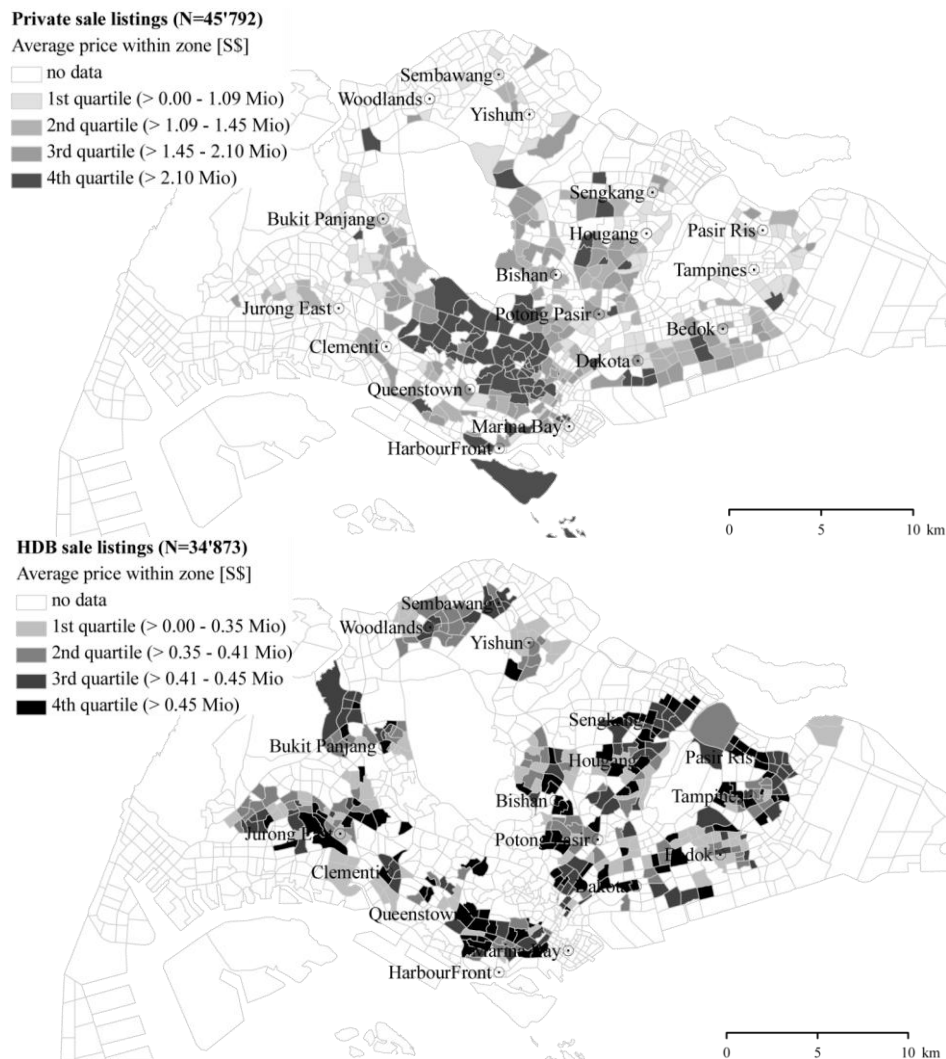


Figure 3. Spatial distribution of average prices in the sale markets

HDB flats are closer to both MRT stations and multi-storey car parks (MSCP). The proximity to MRT stations can be explained with the same arguments as the proximity to bus stops (see above). The proximity to MSCP becomes clear when examining the spatial distribution of MSCP. Many of the 783 MSCP are located in HDB towns (especially around Woodlands, Sembawang, Bukit Panjang, Jurong West, and Sengkang) and very few of them are in the city centre. The differences between asking and transaction price listings are not very large in both cases.

3.2.3 Structural variables

Private sale flats are about fifty percent larger than HDB flats. HDB rental flats - which are considered to reflect the highly subsidized social housing market (Phang, 2007) - are only half as large as HDB sale flats and almost three times smaller than private sale flats. It stands out that there is no significant difference between asking and transaction price data concerning the floor area. The average age of a sold HDB flat is 27.7 years while the equivalent value in the private sale market is 10.5 years. The reason for this difference is that new HDB flats (public new housing market, see Section 1) do not appear yet in the HDB resale listings.

4. MODELING

Six models are estimated in total, representing the different property markets discussed in Section 1. For all models a log-log specification has been chosen, due to its good economic interpretability. For all models the following estimation procedure was followed: (1) stepwise variable selection using OLS, (2) testing for heteroscedasticity, (3) outlier exclusion, (4) OLS and SAR coefficient estimation and final variable selection and (5) a test for spatial autocorrelation. An overview of the models can be seen in Table 1. The number of variables varies for two reasons: not all variables are known for all markets and some have been excluded due to their statistical and substantial insignificance. Lehner (2011) provides an overview of all descriptive statistics and model estimates. All models were tested with Moran's I statistic (Clifford and Ord, 1981) and Lagrange multipliers tests (Anselin and Bera, 1996). In all cases, a SARerr model is chosen. The authors can be contacted for a full overview of all modeling results. The results can be found online as well on <http://www.ivt.ethz.ch/docs/students/sa307.pdf>.

Table 1. Overview of estimated models

| Name | Market | Data type | Number of observations | Number of variables ¹ | SSE |
|---------|----------------|------------------------|------------------------|----------------------------------|-------|
| Model A | Private sale | Asking and transaction | 45'792 | 23 | 492.6 |
| Model B | Private sale | Transaction | 12'467 | 21 | 127.3 |
| Model C | Private rental | Asking | 22'011 | 16 | 308.4 |
| Model D | HDB sale | Asking and transaction | 34'873 | 13 | 175.3 |
| Model E | HDB sale | Transaction | 32'235 | 21 | 85.6 |
| Model F | HDB rental | Asking | 6'351 | 8 | 269.3 |

¹Groups of dummies count as one variable

5. DISCUSSION & OUTLOOK

5.1 Discussion

Modeling results show that it is possible to estimate hedonic house prices by both both using readily available asking prices and transaction prices, combined with data collecting from several online and offline sources. The main difference between the transaction and asking price models can be found in the estimated constant. All other parameter estimates remain in the same range.

Second, the effort to collect spatial variables, such as bus stops, supermarkets and other attributes, in combination with spatial autoregressive models, proves to yield better results than traditional ordinary least squares.

However, the most important driver in house prices remains the floor area and the distance to the CBD, which is in line with other hedonic studies as discussed in Section 1. This is shown in Figure 4, where the scaled coefficients for floor area, construction year, distance to CBD and distance to nearest MRT station are compared. The scaled coefficient for distance to nearest MRT is small as compared to the other variables. The relative large scaled coefficient for distance to CBD also indicates the strong central structure of Singapore which is strongly focused on the CBD, and the main private residential districts lying around the CBD. The main transport aterials, both public and private, are designed to support this. Other locational variables also have a small influence: the estimate for number of bus lines is positive albeit small for models concerning the HBD market, but negative for private dwellings, a bus stop between 200 and 600 meters is considered positive. Proximity to top primary and secondary schools is valued positively across all market segments.

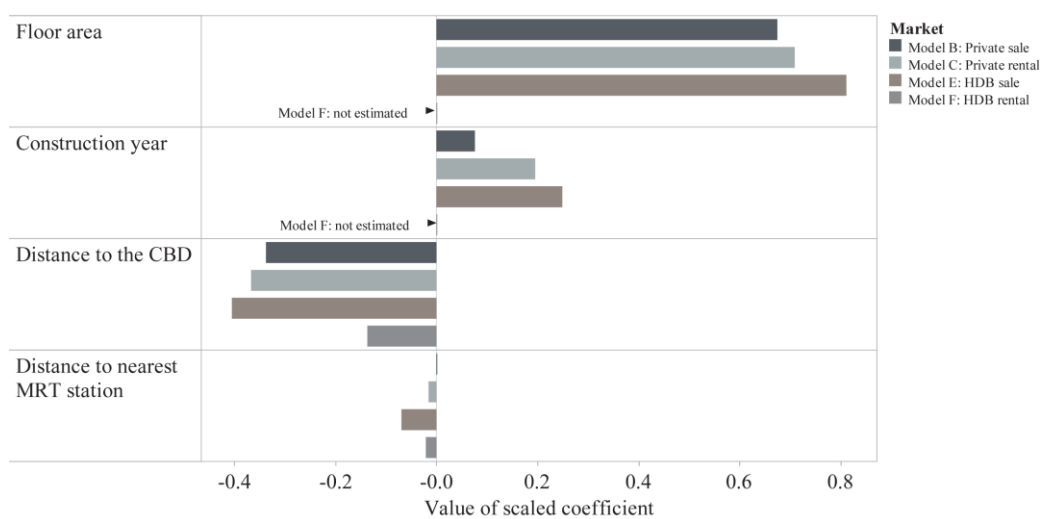


Figure 4. Comparison of scaled estimates of selected variables

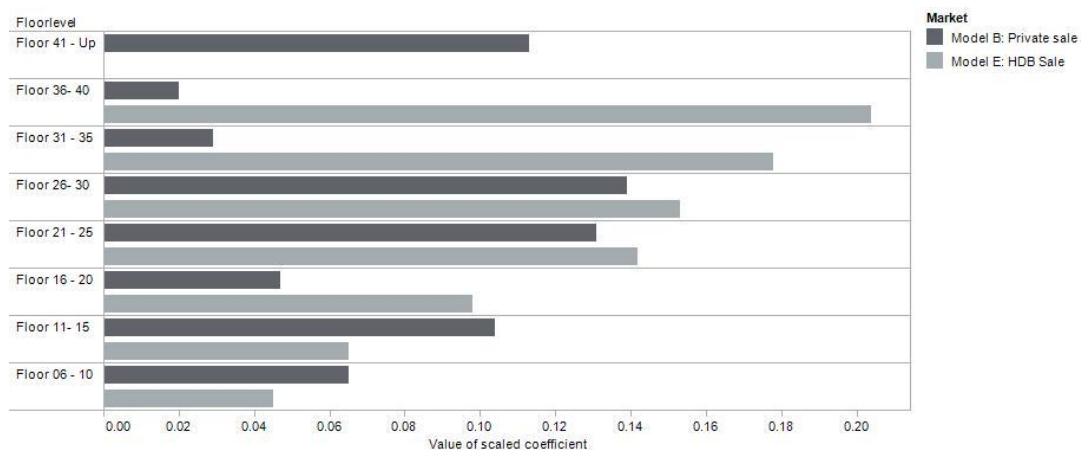


Figure 5. Comparison of scaled estimates of different floor levels

In a dense urban environment such as Singapore, floor level plays an important role and dependent on the market segment. Despite longer waiting times for a lift and higher exposure to sun, people prefer living on higher floor levels, especially in HDB flats. This is shown in Figure 5. It is hypothesized that this is due to the view, intenser daylight, less street noise and the possibility to enjoy a breeze. The pattern is less pronounced for private apartments. This could be to the fact that the height and luxury of private dwelling greatly varies per district.

GWR models offer the opportunity to capture such taste variations. Figure 6 shows varying preferences for floor level. In densely built areas along the East Coast, a flat higher floor level yields a higher price than a flat located more central in less densely built area. Dummy variables representing transaction quarter show a price increase over the last year for both the private and public market.

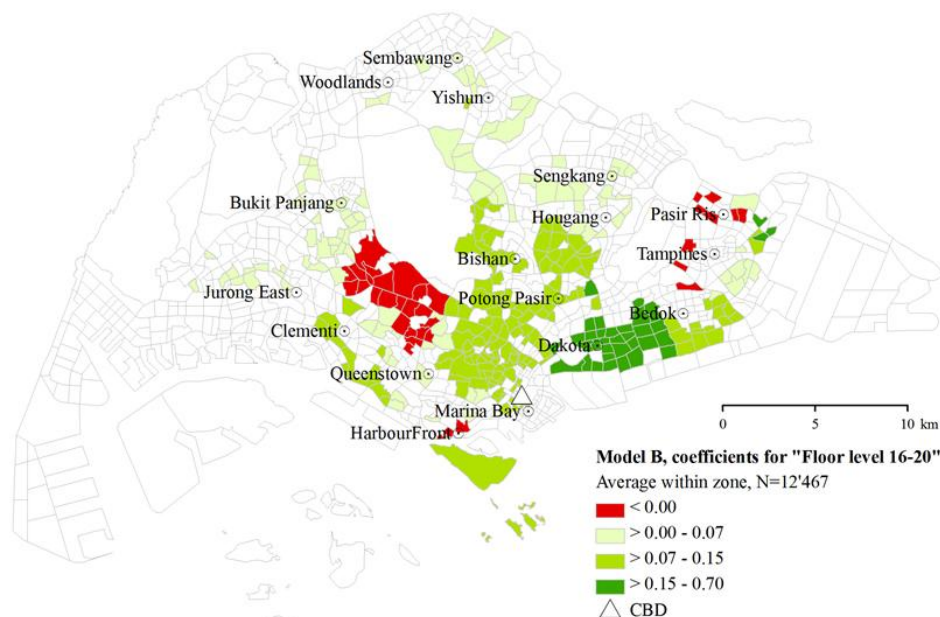


Figure 6. Model B: Spatial variation of structural coefficients

5.2 Outlook

In the near future, the authors plan to include accessibility measures in their models, such as the number of leisure and work opportunities within 30 minutes traveling. Furthermore, the effect of travel time related attributes will be evaluated (both public and private transport). A third topic is to further explore the centric nature of Singapore by incorporating sub-centres in the hedonic models. In addition, a topic that might be of interest is to include variables representing living quality, such as solar exposure, temperature and daylight availability. Finally, the experiences of this study will serve as input for research regarding residential location choice as input for the land-use transport interaction modeling.

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